RAPTOR NESTS AS A HABITAT FOR INVERTEBRATES: A REVIEW

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Abstract

Invertebrates in raptor nests may be classified into three major groups: parasite fauna, animal saprovores, and humus fauna. The parasite fauna includes raptor and prey parasites and their corresponding parasites and predators. The animal saprovore fauna includes the invertebrates associated with the decomposition of such material as carrion, excreta, pellets, and molted feathers. The humus fauna includes invertebrates associated with decomposition of nest material such as litter and wood.

Introduction

Raptors nest in a wide variety of locations below, on, and above the ground level. Occasionally raptors share their nests with other birds, e.g., the Great Horned Owl (*Bubo virginianus*) and the Bald Eagle (*Haliaeetus leucocephalus*) nest together (Austing and Holt 1966); the Screech Owl (*Otus asio*) nests with the Elf Owl (*Micrathene whitneyi*), and woodpeckers, the American Kestrel (*Falco sparverius*) and the Purple Martin (*Progne subis*) (Grossman and Hamlet 1964, Sumner 1933, Wilson 1925). Small birds of several species may nest in Osprey (*Pandion haliaetus*) nests (Zarn 1974). However, nearly every raptor shares its nest with many invertebrates. Referring only to mites in bird nest-box debris, Herman (1936) stated that "an estimate of billions in each nest seems conservative." Actually, according to our work, "thousands" seems to be a more accurate estimate.

Nests of birds and mammals are a habitat for many invertebrates including some domestic pests and arthropods of medical importance. Raptor nest fauna may be divided into three main groups: parasite fauna, animal saprovores, and humus fauna. Parasite fauna of raptor nests includes raptor and prey parasites and their parasites and predators. The animal saprovores include the invertebrates associated with the decomposition of such material as carrion, excreta, pellets, and molted feathers. The humus fauna includes invertebrates associated with nest material such as litter, soil, and wood.

Bird Nest Community Studies

There have been few studies of the entire invertebrate community within nests. Most investigators have only sampled one animal group from a nest, such as fleas or beetles. Others have sampled old nests, without knowing which bird species built or used the nest. Consequently, data on nest invertebrates is scattered in the literature and incomplete.

A few extensive studies of bird nest fauna have been made (Nordberg 1936, Wood-

roffe 1953). Woodroffe and Southgate (1951) studied nests of the House Sparrow (*Passer domesticus*), Starling (*Sturnus vulgaris*) and Robin (*Erithacus rubecula*). In these nests, there was a definite succession of invertebrates. Ectoparasites of the bird dominated during initial nest construction and occupation. After the nest was deserted, scavenging invertebrates were dominant as the feather debris and excreta passed through various stages of decomposition. The final stage of decomposition of nest material was dominated by humus fauna. If the nest was used as a winter roost and reused the next year, then it acted as a refugium, and the scavenging fauna persisted. Open, exposed nests decomposed faster and the scavenging stage was reduced or absent. Differences in the fauna of nests of different bird species were correlated with differences in the composition of the nests.

The successional pattern was not consistent for all birds' nests. Freitag and Ryder (1973) studied Ringbilled Gull (*Larus delawarensis*) nests and found almost no ectoparasites. Saprophagous mite populations, however, peaked after gull egg-laying while predatory mite populations peaked at or after egg-hatching (Freitag et al. 1974). Arthropod numbers averaged 302 per small nest and 876 per large nest (Ryder and Freitag 1974).

Nests may be regarded as habitat islands, and colonization of nests may occur by many means. Some invertebrates may crawl or fly directly to the nest. Considerable numbers are carried into the nest with nesting material. Parasites may be brought to the nest by the bird; other invertebrates may also reach the nest in this manner (Worth 1975). Raptor nests often contain parasites from vertebrate prey species brought to the nest. In addition, invertebrate prey species brought to the site may escape and colonize the nest (Woodroffe 1953). Chmielewski (1970) demonstrated the possibility of endozoic colonization of nests by mites. He fed astigmatid mites to mice, sparrows, and hens and found that 1-7 percent of the mites survived passage through the alimentary canal.

Raptor Nest Fauna

A summary of arthropod nest fauna for American raptor species is presented in tables 1 and 2 although most of these data are not from North American nests. The work of Hicks (1959, 1962, 1971) is an invaluable guide to the insects known from birds' nests. No such checklist exists for arachnids and other invertebrates.

References to mites and ticks from raptor nests are few and often hidden in the literature. Nordberg (1936) lists mites from several raptor nests, but an error in the work confuses the data from Peregrine Falcon (*Falco peregrinus*) and Eagle Owl (*Bubo bubo*) nests. The importance of mites is shown by our findings. We examined a Screech Owl nest and an American Kestrel nest, and each had a total of over 10,000 mites. Samples from two Great Horned Owl nests have yielded 100 and 83 percent mites.

Nest Parasites

The best known group of invertebrates in nests of raptors in North America are the nidicolous raptor parasites. There have been occasional reports of parasites causing the death of raptor nestlings. Bloodsucking *Protocalliphora* larvae attack nestlings of many birds, including raptors (Hill and Work 1947). The maggots attack the feet, eyes, ears, nares, legs, or anus making entry into the body. Nestling songbirds in nest boxes have been killed, e.g., the Bluebird (*Sialis sialis*) and Tree Swallow (*Iridoprocne*

bicolor) (Mason 1944, Owen 1954). Species with open nests are less susceptible. Sargent (1938) found nests of large hawks to be nearly 100 percent infested but found no evidence of mortality. Buckner and Cole (1971) found a young Red-tailed Hawk (*Buteo jamaicensis*) nearly comatose because of larvae in its ear. The bird recovered after removal of the larvae. White (1963) reported extensive mortality in the young Prairie Falcon (*Falco mexicanus*) from these maggots.

Blackflies have caused mortality in nestling Merlin, *Falco columbarius* (Trimble 1975), and Red-tailed Hawks (Brown and Amadon 1968).

Ticks were stated to cause 65 percent mortality of young Prairie Falcons in Colorado from starvation in their first month (Webster 1944). Williams's (1947) observations did not agree with this, but recently Oliphant et al. (1976) reported the deaths of two nestling Prairie Falcons from a massive infestation of a bird tick *Ornithodoros concanensis.*

The tropical feather mite *Ornithonyssus bursa* is known to have been the cause of the death of a captive European Sparrowhawk (*Accipiter nisus*) (Mites 1963). Ian Newton (pers. comm.) observed deaths of European Sparrowhawk nestlings due to mite attacks. Cooper (1972) noted that mites are more common parasites of hawks than ticks and often infest holding facilities. Chiggers may be present in nests, but we know of no instances where they caused death.

The Mexican chicken bug, *Haematosiphon inodorus* (Cimicidae), is related to the common bedbug and has caused mortality in young Prairie Falcons and Red-tailed Hawks (Platt 1975). Infestations may be quite severe, as shown by Lee (1959) who found 1,778 in a single Barn Owl (*Tyto alba*) nest.

According to Cooper (1972) fleas are not common on birds of prey, and we know of no raptor nestling mortality due to fleas. Fifteen species of fleas have been found in Burrowing Owl (*Speotyto cunicularia*) burrows, but many of them came from previous rodent inhabitants of the burrow. Also, prey brought into the nest is the source of many raptor nest fleas.

Ectoparasitic flies—the louse flies (Hippoboscidae) and *Carnus hemapterus* (Milichiidae) suck blood and may be found on birds and in their nests. Owls are important breeding hosts of hippoboscids, and are favorite winter hosts for species for louse flies that exhibit little host specificity. The plumage of owls offers ideal shelter for ectoparasites, and the beak is poorly adapted for preening (Bequaert 1953). Hippoboscids also may transport phoretic Mallophaga and pseudoscorpions to new hosts and nests (Keirans 1975, Bequaert 1953). We know of no fatal nestling infestations of these flies.

Feather lice and feather mites have been found in raptor nests, but they are generally restricted to the bird's body. They may, however, accidentally fall into the nest when transferring to a new host. These feather parasite obligates normally do little harm to a healthy bird but may increase in numbers and affect a bird already sick and unable to preen.

Parasite Load in Nests. The flying squirrel (*Glaucomys* spp.) is colonial in winter, and parasite levels in nest and resting holes sometimes become so high the hole has to be abandoned (Muul 1968). Data is needed on whether such infestation may also occur in winter colonial roosts of raptors like the Short-eared Owl (*Asio flammeus*). Raptors frequently return to the same nest or build another nearby. Possibly high nest parasite levels make the old nest uncomfortable and unsuitable for reuse in another year.

Predatory Behavior of Ants. Although not parasites, fire ants (*Solenopsis saevissima richteri*) and carpenter ants (*Camponotus* sp.) may kill nestling songbirds (Coon and Fleet 1971, Conner and Lucid 1976). Parker (in press) observed ant predation on Mississippi Kite (*Ictinia misisippiensis*) nestlings. Sykes and Chandler (1974) mentioned a possible predatory ant problem in Everglades Kite (*Rostrhamus sociabilis*) nests. In their view, antproof artificial nesting structures would help eliminate threat.

Natural Biological Control. Next predators and parasites of raptor parasitese are important in determining nest parasite population levels. Staphylinid and histerid beetles present in nests often prey on fleas. Many mites and insect larvae prey on fly larvae: *Nasonia vitripennis,* a wasp parasitic on *Protocalliphora,* has been reported from Long-eared Owl (*Asio otus*) nests (Jellison 1940). The exact trophic interrelationships of many nest species are unknown.

Nest Animal Saprovores

Hide or carpet beetles (Dermestidae) are important in causing the decomposition of animal remains in raptor nests, and Balgooyen (1976) observed them in every American Kestrel nest he studied. He described the symbiotic relationship between beetle and falcon as facultative mutualism. This association would be termed passive protocooperation according to Dindal (1975) since mutualism must be obligatory. The falcon provides the beetle with food and shelter, and the beetle disposes of unused animal debris. However, Rothschild and Clay (1952) note that when the larder beetle (*Dermestes lardarius*) is numerous, it may attack and kill nestling birds. It has sometimes bored into the wing bones of young pigeons and eaten the tissue while the bird was still alive.

Skin beetles (Trogidae) are also important in the role of decomposing animal remains. Most trogids eat hair, feathers, and dried skin and are especially common in owl nests. *Trox tytus* has been found only in Barn Owl nests while *Trox striatus* is known only from owl pellets and nests (Vaurie 1955).

Larvae of the clothes moths (Tineidae) eat hair and are common in birds' nests. We have found both moths and carpet beetles in debris from a porch in Syracuse, N.Y., on which an injured Great Horned Owl was kept. The housing of captive raptors may thus serve as a source of infestation of households with these domestic pests.

Scavenging mites and other insects are also involved in the decomposition of the animal remains in the nest. We have found scavenging mites (fig. 1) to be numerically dominant in an American Kestrel nest. Nordberg (1936), however, found that dermestid and trogid beetles were dominant by volume in nests of Peregrine Falcons and Eagle Owls.

Humus Fauna in Nests

The humus fauna includes invertebrates associated with the decomposition of the nest plant material. Many mites and insects such as springtails (Collembola) are involved in the decomposition of litter, moss, and wood, and are brought to the nest along with that material. In a Screech Owl nest we found the humus fauna, especially Oribatid mites (fig. 2) to be numerically dominant.

Conclusions

There is at present little evidence that arthropods are a very common cause of raptor nestling mortality (Keymer 1972). However, there are few data on raptor nest in-

vertebrates. Many raptors are marginal or endangered species. We need to know what invertebrates may be a source of mortality and how frequently it occurs. After investigating the entire nest community and working out details of trophic relationships, biological control measures against any undesirable invertebrates may be possible. Mason (1944) has suggested use of the parasitic wasp *Nasonia vitripennis* to help control *Protocalliphora*. The problem is complicated because other species of maggots are more preferred hosts. At least, as he recommends, one should avoid cleaning out nest boxes until the wasps have hatched.

With the increased use of artificial nests, we have the capability to more carefully control the nest environment as well as its fauna. Possible addition of an inorganic desiccating agent might make nests less favorable as a habitat for parasites, or kill parasitic occupants. Obviously much more study is needed to elucidate the dynamics of the total community of invertebrates in the nest microhabitat.

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Table 1. Known Raptor Nest Arthropods

Raptor	Total Families	Total Species
Haliaeetus leucocephalus	1	1
Aquila chrysaetos	5	6
Pandion haliaetus	6	20
Falco columbarius	2	5
Falco mexicanus	4	4
Falco peregrinus	15	22
Falco sparverius	6	8
Accipiter cooperii	2	3
Accipiter gentilis	8	28
Accipiter striatus	1	4
Buteo jamaicensis	4	5
Buteo lagopus	6	45
Buteo lineatus	2	3
Buteo platypterus	1	3
Buteo regalis	1	1
Buteo swainsoni	4	5
Buteogallus anthracinus	1	1
Circus cyaneus	4	5
Elanoides forficatus	1	1
Elanus leucurus	1	1
Aegolius acadicus	1	1
Aegolius funereus	12	31
Asio flammeus	8	46
Asio otus	17	40
Bubo virginianus	8	11
Glaucidium brasilianum	1	3
Micrathene whitneyi	1	1
Nyctea scandiaca	2	5
Otus asio	4	6
Speotyto cunicularia	21	39
Strix nebulosa	1	1

Strix occidentalis	1	1
Strix varia	1	2
Surnia ulula	1	1
Tyto alba	22	40
Cathartes aura	3	4
Coragyps atratus	1	2
Gymnogyps californianus	1	1

Table 2. Insect Families Common in Raptor Nests

Diptera	*Coleoptera*	*Hemiptera*	*Siphonaptera*
Calliphoridae	Dermestidae	Cimicidae	Ceratophyllidae
Helomyzidae	Histeridae		Hystrichopsyllidae
Hippoboscidae	Ptiliidae		
Milichiidae	Staphylinidae		
Muscidae	Trogidae		
Simuliidae			

Figure 1. A hypopus, the nonfeeding transport stage of the mite *Lardoglyphus* (Astigmata: Acarina), is phoretic on dermestid beetle larvae. This specimen is a new species found in a Kestrel nest. A description of it is in preparation.

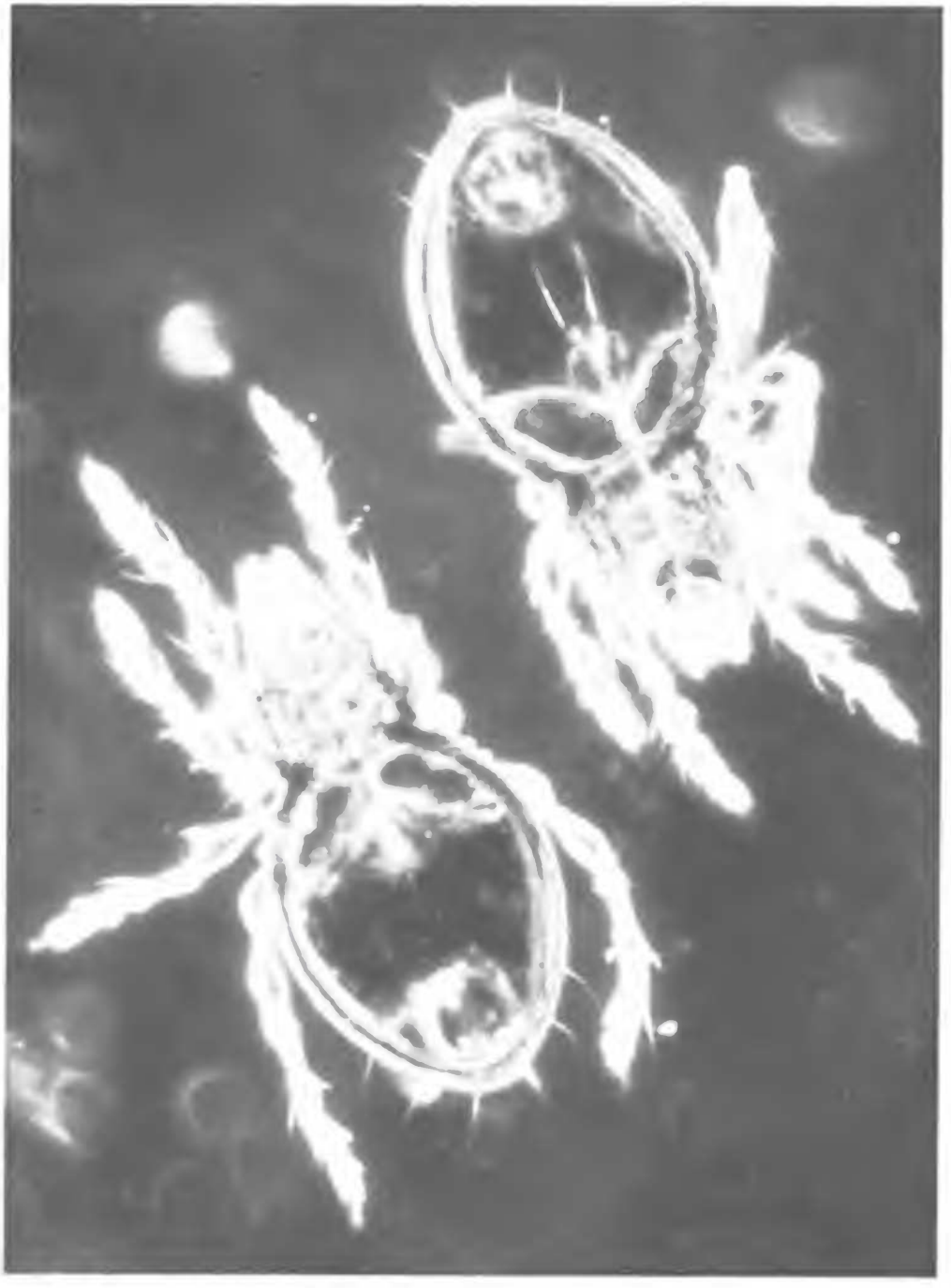

Figure 2. An oribatid mite, *Oppia clavipectinata* (Oribatei: Acarina), from a Screech Owl nest.